NOVA Mechanical Engineering for TASD

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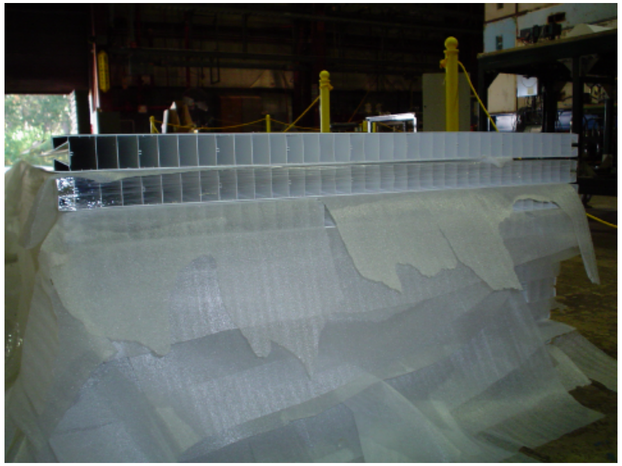
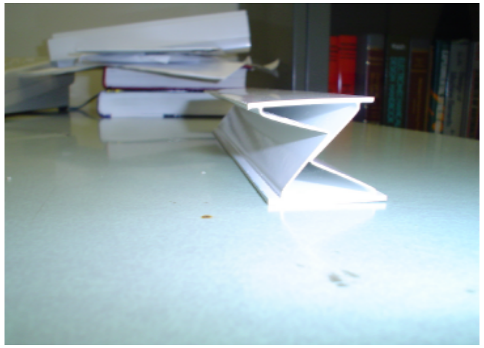
Talk Outline

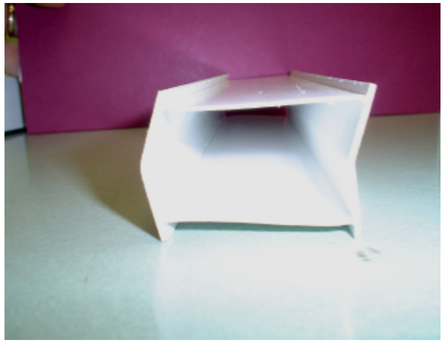
- Physical Testing of Extrusions for FEA comparison
- PVC property testing
- Epoxy Property testing
- Design and Analysis of TASD structure and extrusions
- “Half-scale” 4 plane prototype
- Other Mechanical Tasks
- Mechanical Research and Development Program for NOvA - Nova Note #54

Physical Testing of Extrusions for FEA Comparison

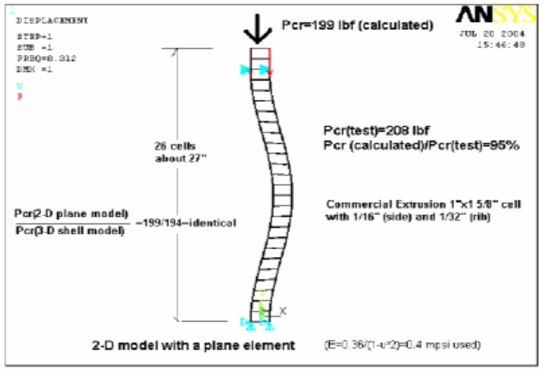
- Use commercial extrusions (34 cells 1″ x 1 5/8″ with 1/16″ wall and 1/32″ rib)
- Investigate the ability of FEA to accurately model behavior of PVC extrusions.
- Measure strength and performance of PVC extrusions.
- Buckle tests on full panels, and individual cells.

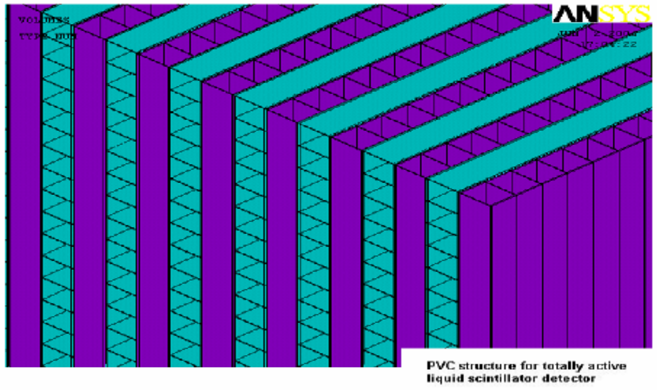






Physical Testing of Commercial Extrusions for FEA Comparison





	Experimental Data	FEA 2-D model	FEA 3-D model	Analytic Solution
Collapsing Load (lb)	208	199	193	180
Difference with test data (%)		5%	7%	17%

- Buckle test on full panel.
- Simulates a horizontal extrusion supporting the entire load of the extrusions above it – this bounds the problem.
- TASD Extrusion must support 52.7 lbs./in.
- Commercial Extrusion Buckling occurred at 8.7 lbs/in. –confirmed by FEA by Ang Lee

PVC Property Tests

- Specification of composition and maximum working stress will be determined through measurement of PVC and extrusion properties.
- Need to understand the effect of TiO2 and other components on strength.
- Need to understand Creep.
- Results of this R&D will be used to write a material specification for extrusions

PVC Property Tests

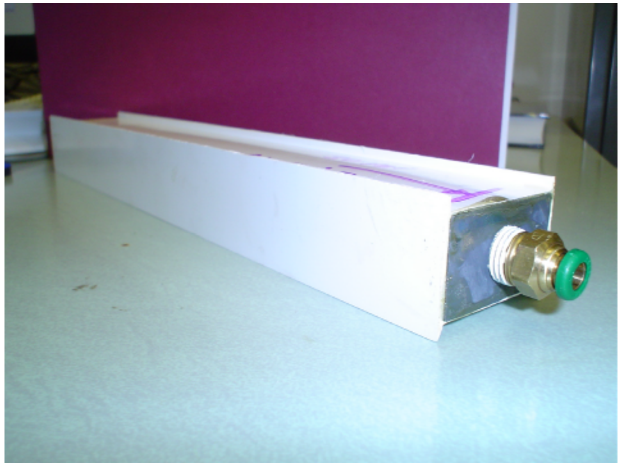
- Commercial extruder is supplying extruded sheets of PVC with different levels of TiO_2 and other components for testing.
- We are planning/thinking of getting extrusion with different levels of TiO_2 from the custom extruder as well.
- Testing of strength, creep will be conducted according to ASTM standards
  - D6436-02 Standard Guide for Reporting Properties for Plastics and Thermoplastic Elastomers
  - D6112-97 Standard Test Methods for Compressive and Flexural Creep and Creep-Rupture of Plastic Lumber and Shapes
  - D1784-03 Standard Specification for Rigid PVC Compounds
  - D882-02 Standard Test Method for Tensile Properties of Thin Plastic Sheeting
  - D695-02a Standard Test Method for Compressive Properties of Rigid Plastics
  - D638-03 Standard Test Method for Tensile Properties of Plastics

Epoxy Property Testing

- There are 2 applications for glue in the TASD structure – to seal the extrusion ends and to attach extrusions to each other.
- UMN and ANL have done some tests already. Results will be used to select the glues that will be used in additional tests and on the 4 plane prototype at ANL.
- Epoxy tests will be conducted according to ASTM standards.
  - D6465-99 Standard Guide for Selecting Aerospace and General Purpose Adhesives and Sealants
  - D4896-01 Standard Guide for Use of Adhesive Bonded Single Lap-Joint Specimen Test Results
  - D3164-03 Standard Test Method for Strength Properties of Adhesively Bonded Plastic Lap-Shear Sandwich Joints in Shear by Tension Loading
  - D3163-01 Standard Test Method of Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading
  - D1144-99 Standard Practice for Determining Strength Development of Adhesive Bonds

Epoxy Testing/Extrusion Seals

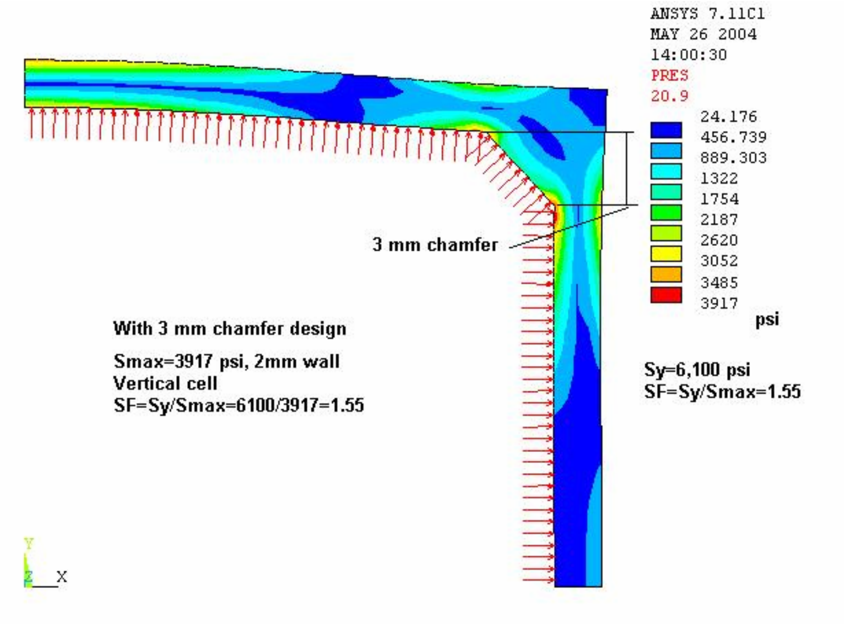
- Some preliminary tests have been conducted using different epoxies and designs for end seals.
- Samples are glued and then pressurized.



	# of Samples	Failure Pressure (psi)	Standard Dev.
PVC Cement	5	44.0	29.2
3M 810	5	34.0	4.1
Araldite	5	12.0	4.4
EP1056-LV	5	10	0
EP1056-LC	5	13.0	2.0

Design and Analysis of TASD Structure and Extrusions

- The testing on the commercial extrusions, PVC and glue will be used as the basis for final design of the TASD structure and extrusions.
- Outstanding issues:
  - Size of inside chamfer/fillet
  - Rib and wall thickness
  - Stresses in epoxy between extrusions
  - Restraint that is needed by bookends.
  - Understand what happens when cell leaks and pressure is supported by thin walls.



Model of Vertical Cell under pressure that showed that the corner chamfer reduced stress concentrations in the corners.

FEA Calculation by A. Lee - FNAL

Design and Analysis of TASD Structure and Extrusions

- Future design and analysis plan:
  - Perform all required FEA analysis to mimic the tests currently being conducted on the commercial extrusion.
  - FEA modeling of the proposed TASD extrusion geometry that reflects past analysis as well as knowledge gained from PVC testing and physical testing of the commercial extrusions.
  - FEA modeling of the 4 plane mechanical prototype being constructed at ANL.
  - Detailed FEA analysis of TASD assembled structure.
  - When prototype extrusions of the TASD extrusion geometry have been produced physical testing and FEA modeling of physical testing on cell samples similar to the tests conducted on the commercial extrusion.

TASD Assembly

- There are two thoughts on assembly – assembling 1 plane at a time like Minos or assembly of multiple planes (20tons) at a time.
- Needed R&D
  - Evaluate the flatness of large extrusions and how this affects the assembly.
  - Evaluate the minimum amount of epoxy needed for structural strength and to eliminate bowing of the extrusion.
  - Evaluate methods for compressing extrusions together and maintaining required flatness and straightness of plan.
  - Cost and design of fixtures needed.
  - Time and effort required for assembly.
- Design work is continuing on both methods – "half-scale" prototype (see Rich's talk) will address some of these issues.

Other Mechanical Tests

- In addition to the basic mechanical design and analysis of the TASD structure outlined here the following mechanical tasks also need to be investigated:
  - Scintillator filling/handling/mixing/distribution (IU)
  - Assembly method. (ANL, FNAL)
  - Detailed design of module components. (UMN)
  - Design of bookends. (ANL, FNAL)

The R&D described in this talk is part of an overall Plan

- 1.0 Design of TASD Structure
- 2.0 R&D of Assembly Process
- 3.0 R&D of Scintillator/filling process
- 4.0 Module Design
- 5.0 Full Scale Prototype Design
- 6.0 Facility Design

Conclusion

- Physical testing has begun on commercial extrusions to confirm the ability of FEA to model the TASD structure and to give insight into the performance of the extrusions.
- An extensive testing program is under way to determine epoxy and PVC properties.
- Extensive analysis of the TASD structure is planned using the information gained from the PVC and epoxy tests and testing of the commercial extrusions.
- Additional mechanical issues need to be addressed at the same level of detail in the near future.
- “Half-scale” 4 Plane prototype construction has started.